

# A simplified screening test for identifying people with low vision in developing countries

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*Simple but effective tests have been produced for screening subjects with low vision in developing countries. These tests of distance and near vision, based on the E test, were evaluated and validated in trials with people aged 4–90 years, and have been field tested in the health, education and rehabilitation services in 32 developing countries. Their sensitivity and specificity as screening tools for low vision have been calculated: sensitivity of 85% and specificity of 96% for the distance vision test, and sensitivity of 100% and specificity of 84% for the near vision test. The content and format of the tests have been demonstrated to be appropriate for developing countries, and their effectiveness for screening for low vision has been confirmed.*

## Introduction

Some 90% of the visually impaired in the world live in developing countries (1). The provision of appropriate vision tests for use in these areas, where trained eye care staff and resources are scarce, is therefore imperative. For example, in Africa there is, on average, one ophthalmologist per million population (2); despite current efforts focused on training, there is still an enormous shortage of skilled staff for basic eye care and to help prevent blindness.

The appropriateness of vision tests is determined by their technological aspects and content, and the training required to administer them. To screen the vision of large numbers of people in a developing country it is often necessary to recruit untrained people within a community. The tests they administer must therefore be simple to learn and to use, with results that are easy to interpret. Test materials should be sturdy and capable of being easily transported. In addition, the test adopted should not be culture-specific or depend on literacy so that it can be used in any part of the world.

Such screening helps to detect people with impaired vision who may require referral for treatment, and to identify those with potentially normal or low vision but who have been regarded as blind. For example, many students in programmes and schools for the blind in developing countries have usable vision and are potential print-readers, but because of some visual impairment they were regarded as blind. In East Africa, as many as 80% of students regarded as blind and placed in schools for the blind or in special programmes for the visually impaired had previously unidentified low vision; many of them were taught using nonvisual methods such as Braille (J. Keeffe & G. Nyaga, personal communication). The results of tests of near and distance vision, together with assessments of functional vision, can therefore help to identify suitable methods for rehabilitation and education, including the most appropriate reading format (Braille or print) and whether low vision devices may be useful.

Our kit for assessment of low vision in developing countries contains a visual acuity test-card, a pin-hole mask to detect refractive errors, and two manuals with instructions for visual acuity testing, the assessment of functional vision, and background information concerning the effects of low vision (3). The tests are suitable for use with children (above about 5 years of age) and adults. This article describes the development and validation of these tests of distance and near vision.

## Methods

The test card adopted was similar to one previously developed by and available from WHO, which used two sizes of optotypes on a small square plastic card.

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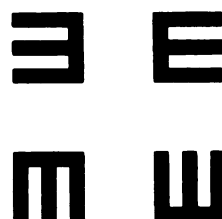
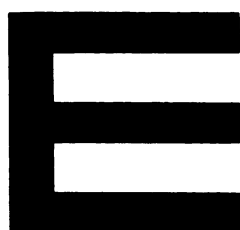
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Fig. 1. **The Visual Acuity Test Card.** The upper panel shows the optotypes which appear on the outside of the card when it is folded in half. The near vision test types and the instructions, which appear on the inside faces, are shown on the lower panel.



#### NEAR VISION



Demonstrate close to the person how to do the E test - show the direction the Es point. Test near and distance vision to find the smallest E each person can see.

#### DISTANCE VISION

1. Test with the 4 small Es at 6 metres.  
Vision is normal (6/18 or better) if at least 3 out of 4 small Es can be seen. If able to see smallest Es on near vision test, no more testing needed. If not able to see at least 3 of the small Es, test with the large E.
2. Test with the large E at 6 metres. Turn the card to test the E in 4 different directions. If the Es are seen, vision is 6/60. Check vision with pinhole - if improved refer for testing for spectacles; if not improved, refer to eye specialist. If not able to see at least 3 of the large Es, test at 3 metres.
3. Test with the large E at 3 metres. Turn the card to test the E in 4 different directions. If at least 3 out of 4 Es are seen, vision is 3/60. Repeat the pinhole procedure for number 2. If not able to see at least 3 of the large Es, test with pinhole and refer to eye specialist for possible treatment.

#### NEAR VISION

4. Let the person hold the near vision test card as close as he/she wants. Test from the largest to the small Es. At least 3 out of 4 must be correct in each line before testing the next. If only the largest (N48) size can be seen, check if magnifiers will help and refer for testing for spectacles and to an eye specialist for possible treatment. The medium size (N20) is similar to the print in large print books. The smallest size (N8) is similar to the print in books and magazines.

If near vision card is used at 6 metres and the large Es are seen, vision is 6/6 (normal).

The test procedures are explained in Book 1 - Screening for Impaired Vision. Testing Visual Acuity.

Either the illiterate, directional E or the Landolt rings were used. The new plastic visual acuity card measures 37cm × 18.5cm; when folded in half, the resulting square has optotypes for testing distance visual acuity on the outside faces. On the inside, the near vision test is printed on one side and the instructions for using both tests on the other (Fig. 1).

### Screening distance vision

The purpose of the distance vision test is to screen for normal or low vision, and not to measure the distance visual acuity accurately. Thus, the test differences (use of a single letter or a group of four letters) and consequent variation in contour interac-

tion are not considered drawbacks. Of course, for an accurate measure of visual acuity these factors would need to be controlled (4, 5). It is recommended (see test instruction, Fig. 1) that distance vision be screened with at least four optotypes, irrespective of the level of vision. The criterion adopted for passing any level of vision is 3 out of 4 Es correct. Distance vision is tested by first using the set of four E targets, which are 18m size letters. If 3 of the 4 targets are correctly identified at a test distance of 6 metres, vision is classed as "normal", i.e. 6/18 or better, and no further distance vision testing is required. If 3 of the 4 Es are not correctly identified, the large E (60m size) is presented in four different orientations. If 3 of the 4 presentations are correctly identified, the

person has low vision of 6/60 or better. If they are not correctly identified, the test should be repeated at a test distance of 3 metres.

Irrespective of the finding with the large E, it is recommended that vision be retested with a pinhole. If vision is improved, a significant refractive error may be present and, if possible, the person should be referred for optical correction. If vision does not improve, it is most likely that an ocular disease is present and, where appropriate services exist, referral should be made for investigation and possible treatment of the disease. By rotating the card, the symbols can be orientated differently to avoid memorized responses when testing binocularly, monocularly and with the pinhole.

### Screening near vision

To overcome differences in language or literacy within and between countries, the E symbol was also adopted for the near vision test. This test contains three sizes of optotypes rather than the usual six or more. The point system of designating print size was adopted (6, 7). The first version of the test used two sizes, N8 and N20. Feedback after testing indicated that a larger size was also necessary to identify people with usable low vision, so N48 was added. The print sizes used are given in Table 1 in points, logMAR and M notations.

As the exact heights of letters vary with different fonts, the heights of letters in numerous tests were measured to establish a common or average size at each of the chosen print sizes. The E at each of these sizes is equal to the size of the body of lower case letters, i.e., the height of an "e" or the circular component of "d". The E is constructed using the Snellen principle for the height, width and spacing of gaps (8). Contour interaction is controlled by having the spacing between Es equal to the width of the E for that line, and the between-line spacing equal to the height of the Es in the line above.

The smallest optotypes (N8) approximate the size used in regular print books and newspapers. The N20 Es are similar to the print size used in special large-print books. The largest size (N48) approximates the size of print used in headings, labels or

posters. It is also the size of the 6/6 optotype. Therefore it should be noted that if the N48 line is correctly recognized at 6 metres, distance visual acuity is 6/6.

The purpose of the test is to give a measure of functional vision for near tasks by estimating threshold print size and not measuring near visual acuity *per se*, hence no standard test distance is required. The test card can be held at whatever distance gives optimum near vision for each person, and the test distance should be recorded. It may need to be emphasized that children can hold material very close to their eyes to obtain natural or relative distance magnification. The person being tested is asked to indicate the direction of the Es, starting from the largest symbols. Again, the pass criterion is 3 out of 4 correct. If the smallest (N8) symbols are correctly identified, then near vision is regarded as functionally normal. If the medium size (N20) is correctly identified, these persons should be able to make use of their low vision but should be referred for optical and/or medical investigation. It is recommended that if only the largest (N48) size can be recognized, magnification devices may help and there should be referral for investigation.

### Field testing in developing countries

Four separate series of field tests were conducted over 3 years by health workers, educationists and community-based rehabilitation workers in 32 countries in the Pacific region, Asia, Africa and eastern Europe to assess whether the materials performed satisfactorily and met the needs of the different settings. The test-card, accompanying booklets, and evaluation forms were sent by mail to investigators in developing countries who needed to test the vision of people in current programmes or to conduct vision screening. The administration of the test-card by previously untrained users was observed (by the first author) to ascertain whether correct procedures were being used. This author used the test in eye care programmes, and in community-based rehabilitation and educational centres in the Philippines, Fiji, India, Kenya, and Uganda. The final version of the test-card was used in the assessment of 127 students aged 5–20 years in schools for the blind in Kenya and Uganda. These students were part of the same sample assessed by Silver et al. (9), except for the exclusion of those found to have no perception of light. The results of the screenings were compared with the comprehensive assessment results from Silver et al. (9), using  $\chi^2$  tests.

Evaluation forms were completed after each series of field tests. Information collected included whether the instructions were understood and could be followed, and which optotype (the Landolt ring or

Table 1: Equivalent print sizes according to the point system, M units (metric equivalents) (ref. 5), and logMAR at 25 cm (ref. 7)

Points	M units	LogMAR
N8	1 M	0.6
N20	2.5 M	1.0
N48	6 M	1.4

**Table 2: WHO categories of visual impairment and the equivalent visual acuities in the new test of distance vision and on the Snellen test chart**

WHO category	New test	Snellen chart
"Normal" vision	6/6, 6/18	6/6, 6/9, 6/12, 6/18
Low vision	6/60, 3/60	6/24, 6/36, 6/60, 3/60
Blind	<3/60	<3/60

the E) was preferred. Appropriate changes were made between each series of field testing.

### Validation

The sensitivity and specificity of the low-vision screening test was assessed and compared with conventional vision tests. The sensitivity of a test (i.e. the percentage of correct referrals) indicates the probability that the test will correctly identify people who have low vision. The specificity (i.e. the percentage of correct non-referrals) is the probability that the test will correctly identify those people who have normal vision.

Owing to the lack of facilities for accurate assessment of distance and near acuities during the field trials, which is why these screening tests are needed, the validation of the tests was conducted at the Royal Victorian Eye and Ear Hospital in Melbourne. Free and informed consent was obtained from all participants. Tests of both distance and near vision were administered by a masked examiner to 125 consecutive patients aged 4–90 years attending clinics at the hospital. The sample included people with albinism, age-related macular changes, cataracts, aphakia or pseudophakia, and refractive errors. Many had no significant ocular abnormalities. Best-corrected distance and near vision were tested binocularly following the instructions for the vision tests in order to replicate procedures used in the field. Tests used for comparison were the traditional Snellen test charts using letters or Es for distance visual acuity, and the Sheridan Gardiner (SG) letter-matching or, for sizes above N18, the letter-matching booklet of the Near Vision Test for Children (NVTC)<sup>a</sup> for near visual acuity. Visual acuities measured with these conventional tests were gathered as part of routine clinical testing which was carried out on the same day by a different examiner.

Direct one-to-one correspondence between visual acuities from the conventional charts and the screening tests is not possible, and is not required considering the purpose of the test. Measures of

**Table 3: Three measures on the new test of near vision and their SG (Sheridan Gardiner) and NVTC (Near Vision Test for Children) equivalents**

New test	SG or NVTC
N8 (normal)	N5, N6, N8
N20 (impaired)	N10, N12, N16, N18, N20
N48 (poor)	N24, N32, N40, N48

visual acuity from the Snellen test and the SG and NVTC were grouped to list equivalent measures with the new tests (Tables 2 and 3). The WHO categories are given for each group of distance visual acuities.

## Results

The new tests of distance and near vision were successful in both developing countries and hospital clinics in Australia, where they included children as young as 4 years and people who did not speak the same language as the tester. The lack of a common language was not a serious obstacle because the test could be demonstrated.

Of the 127 students attending schools for the blind in Kenya and Uganda, over 60% were categorized as low vision on the basis of the distance-vision test results (Table 4), even though the majority of the students were being educated using nonsighted methods such as Braille. The numbers of students in each vision category were not significantly different from those obtained in a similar population by Silver et al. (9) ( $\chi^2$  test = 3.1;  $P$  = 0.2). Near-vision testing revealed that 61 (49%) of the students had near vision within the normal range and an additional 43 (34%) had the potential to read large print or regular print with magnification (Table 4).

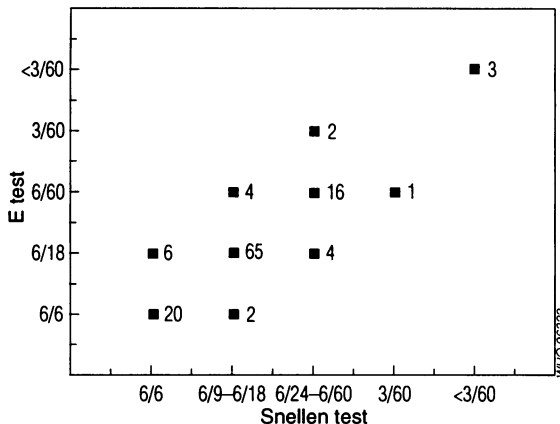
**Validation.** The two subjects (out of 125) who could not complete the validation testing in the Royal Vic-

**Table 4: Results of distance and near vision testing in schools for the blind in Kenya and Uganda ( $n$  = 127)**

	No. of students
<i>WHO category:</i>	
"Normal" vision ( $\geq 6/18$ )	14
Low vision ( $< 6/18$ to $3/60$ )	78
Blind ( $< 3/60$ )	35
<i>Near vision:</i>	
N8	61
N20	43
N48	9
No response ( $> N48$ )	14

<sup>a</sup> Published by Options Australia, Canterbury, Victoria, Australia.

Fig. 2. Scatter plot of distance visual acuity results by the E test and the Snellen test. The numbers on each coordinate indicate the number of people and the results obtained on the respective tests. For example, the point near the lower left corner shows that 20 people achieved visual acuity of 6/6 on both tests.



torian Eye and Ear Hospital were young children with intellectual disabilities in addition to impaired vision. Data from the screening tests and conventional visual acuity tests were therefore available from 123 subjects; of these, 104 (85%) showed the same result from both tests of distance visual acuity (Fig. 2). In all, 115 (93%) were determined to be in the same visual acuity category (i.e., normal, low vision, or blind) (Table 5).

Four subjects (3%), who would not have been detected or correctly referred by using the screening

Table 6: Comparison of results in the new near vision test with the conventional (SG and NVTC) at the Royal Victorian Eye and Ear Hospital. The figures in the horizontal rows were obtained with the new E test, i.e. 27 and 8 were found to have low vision. The figures in the vertical rows were obtained with the SG or the NVTC

	Conventional tests:	
	"Normal" vision	Low vision
Simplified test:		
Low vision	8	27
"Normal" vision	42	0
	Sensitivity 100%	Specificity 84%

test, were found to have low vision on Snellen visual acuity testing (false negatives). A further four (3%) were detected by the new test but had visual acuities of 6/18 or better (false positives). Thus, there were 8 (6%) incorrect referrals. The sensitivity (percentage of correct referrals as low vision or blind) was 85% and the specificity (percentage correctly identified as normal vision and not requiring referral) was 96%.

Of the 77 whose near vision was tested, 69 (90%) achieved comparable results with the new screening test and the conventional clinical tests (Table 6). All 42 subjects who could see N8 on the new test could name or match letters from N8 to N5 on the SG or NVTC. Eight of the 35 who read N20 but not N8 on the new test could recognize smaller letters between N20 and N8 on the tests used for comparison. Of the total number, 10% would have been referred with "low vision" which they did not have. The sensitivity and specificity of the near test were 100% and 84%, respectively (Table 6).

Table 5: Comparison of results in the simplified distance vision test with the Snellen test at the Royal Victorian Eye and Ear Hospital. The figures in the horizontal rows were obtained with the new E test, i.e. 4 and 19 were found to have low vision. The figures in the vertical rows were obtained with the Snellen test. Three were in the blind category in both tests

	Snellen test:		
	"Normal" vision	Low vision	Blind
Simplified test:			
"Normal" vision	93	4	0
Low vision	4	19	0
Blind	0	0	3
	Sensitivity 85%		Specificity 96%

## Discussion

**Size of optotypes.** The use of two sizes of optotypes for distance visual acuity is adequate for screening purposes and to establish basic information for an assessment of functional vision. By testing at 6 and 3 metres when needed, these sizes permit classification of acuity according to the broad WHO categories of "normal" vision, low vision, or blindness (10).

The near vision test is used to determine whether there is useful vision for near tasks, the approximate print size for reading, and whether referral is warranted for correcting refractive errors or prescribing low vision devices. The near vision of those who can recognize the smallest Es could be

described as within normal limits; recognition of only the larger sizes indicates useful near vision but with reduced ability to discriminate detail. If the largest size cannot be seen even at a very close distance, nonvisual methods for accessing print and other information should be considered.

**Test symbols.** Other tests for screening vision, which have been developed for nonreaders because of their age or illiteracy and for people with multiple disabilities, are the Lighthouse cards (11), Kay pictures (12), the Allen cards (13) and the LH symbols.<sup>b</sup> The pictures in these tests have been selected because of their familiarity and their ease of recognition (12). The pictures are often of objects that are common in industrialized countries, but not in developing countries where there are problems due to unfamiliarity with the pictures across cultures. There is less of a problem in the LH tests<sup>b</sup> where the more stylized symbols do not represent unique objects.

Symbols for illiterate persons (the E chart, the Landolt ring and Sjögren's Hand) have been used extensively and recommended in screening programmes (13, 14–18). Use of the E chart or Landolt ring may be problematic in young pre-school children because of the directional, left–right orientation of the symbols (13), but they have been used and are recommended from the age of 5 years (11, 18).<sup>b</sup> The effectiveness of the E test will depend on the age of the person being screened and the purpose of screening. Weale has drawn up a screening protocol for use by teachers to detect children with defective vision who need referral for eye care (18); the screening instrument is an E chart with three sizes of E for testing distance vision.

The test procedure for the E chart and the Landolt ring is simple to explain, and language barriers can easily be overcome. There is also the advantage that one person is able to administer the test alone. In our project, both the E chart and Landolt ring were used for distance and near testing in developing countries. Feedback from a majority of testers in different countries indicated a preference for the E chart. The field testing was predominantly with, but not restricted to, school-age children.

The E chart, which does not require reading of numbers or letters, was adopted for the test of near vision. This test indicates the amount of detail that can be discriminated; it is not a reading task and only assesses the threshold print size. Reading is not

the sole or, for many people, a relevant near-vision task.

An advantage of the E chart or the Landolt ring is that the symbols can be repeatedly shown; with different orientations they remain an intelligible test object, because the direction of the E or gap in the ring can be changed with each exposure of the letters. With pictures, numbers or other symbols, this rotation is not possible so that many optotypes at each acuity are needed or two test cards are required. Large or multiple test cards are neither feasible nor desirable in field settings.

**Relevance to developing countries.** Qualitative feedback from users of the test card in developing countries has indicated that the format and content employed are suited to local needs. The acuity test card is appropriate, easy to learn, and simple to use in a variety of settings.

The test also performed well in the validation study. None of those with low vision was missed with tests for near vision and only 3% for distance vision. Given the simplicity of the tests, these are highly acceptable figures. In a review of the accuracy of vision screening techniques used in developed countries, Schmidt found considerable variation between equipment and procedures used for screening (19). The total proportion of incorrect referrals varied from 0% to 58%, but the criteria for referral were stricter than those recommended for developing countries. Only when the vision screening included an eye examination did the proportion of over- and under-referrals fall below that found in this study.

The difference in performance between our near vision test and the SG and NVTC tests may be due to the types of charts used. The near vision test used three symbols with uniform spacing, in equal logarithmic steps of sizes according to the principles described by Bailey & Lovie (4) (Fig. 1). Discrimination and recognition of optotypes in this format are more difficult than the well-spaced or single letters used in the SG and NVTC tests.

The field testing of these low vision screening tests during their development has ensured that they are appropriate for use in developing countries. The tests satisfactorily categorize people as having “normal” vision, low vision, or blindness. The results can be used to make decisions concerning referrals for treatment or correction of refraction and, in conjunction with findings from the assessment of functional vision, for assessment of low vision or for rehabilitation. This study has confirmed these low vision tests as valid instruments in the situations described.

<sup>b</sup> **Hyvarinen L.** Measurement of visual acuity in visually impaired children. *Transactions of the Vth International Orthoptic Congress, Lyon, France, 1984: 91–95.*

## Résumé

### Test simplifié pour le dépistage de la perte de vision dans les pays en développement

En raison du manque de personnel qualifié et de ressources dans le domaine des soins ophtalmologiques, il est impératif de disposer de tests utilisables dans les pays en développement pour identifier les personnes ayant un défaut de vision. La qualité des tests de vision est déterminée par leur technologie, leur contenu et la formation nécessaire pour leur exécution. Les tests utilisés dans ce contexte doivent être simples à apprendre et à exécuter, et donner des résultats faciles à interpréter. Ils doivent être indépendants de la culture locale et du degré d'alphabétisation, de façon à pouvoir être utilisés partout dans le monde.

Le dépistage aide à identifier les personnes présentant un défaut de vision et susceptibles d'être orientées sur un service spécialisé pour y recevoir un traitement, et à identifier les personnes dont la vue est potentiellement normale ou faible mais qui ont été classées comme aveugles. L'article décrit la mise au point et la validation de tests de vision lointaine et rapprochée, imprimés sur une fiche unique pliée en deux (37 cm × 18,5 cm).

Quatre séries d'essais pratiques ont été réalisées par des agents de santé, des éducateurs et des agents de réadaptation dans 32 pays de la région du Pacifique, d'Asie, d'Afrique et d'Europe orientale pour s'assurer que le matériel donne des résultats satisfaisants et qu'il répond aux besoins des populations concernées. La version définitive de la fiche de test a été utilisée pour évaluer la vision de 127 élèves âgés de 5 à 20 ans fréquentant des écoles pour aveugles au Kenya et en Ouganda. La sensibilité et la spécificité du test de dépistage de la perte de vision ont été évaluées et comparées à celles de tests classiques pratiqués sur 125 patients âgés de 4 à 90 ans dans un hôpital australien.

Les nouveaux tests de vision lointaine et rapprochée ont donné de bons résultats aussi bien dans les pays en développement que dans des hôpitaux australiens, où ils ont été exécutés sur des enfants de 4 ans et sur des personnes ne parlant pas la même langue que l'examineur. La sensibilité et la spécificité étaient respectivement de 85% et 96% pour les tests de vision lointaine et de 100% et 84% pour les tests de vision rapprochée.

L'utilisation de deux tailles d'optotypes pour l'acuité visuelle à distance convient aux fins de dépistage et pour obtenir des informations de base en vue de l'évaluation de la vision fonctionnelle. Présentés à 6 mètres et à 3 mètres, ces optotypes

permettent de classer l'acuité visuelle du patient selon les grandes catégories de l'OMS, à savoir vision normale, perte de vision ou cécité. Le test de vision rapprochée sert à déterminer si le patient a une vision utile pour exécuter des travaux de près, quelle est la taille de caractères nécessaire pour la lecture, et s'il est justifié d'orienter le patient en vue d'un traitement ou d'une correction des vices de réfraction.

L'information qualitative recueillie auprès des utilisateurs des fiches dans les pays en développement montre que la présentation et le contenu de ces tests sont adaptés aux besoins locaux. Les tests ont permis de classer correctement les sujets examinés comme ayant une vision normale, une perte de vision ou une cécité. Ces résultats peuvent être utilisés pour décider d'orienter le patient en vue d'un traitement ou d'une correction des vices de réfraction et, s'ils sont joints aux résultats de l'évaluation de la vision fonctionnelle, de l'orienter en vue d'une évaluation de la perte de vision ou d'une réadaptation. Cette étude a confirmé la validité de ces tests dans les contextes examinés.

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